

**PATENT COOPERATION TREATY**  
**PCT**

**INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY**

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference 39174WOP00	<b>FOR FURTHER ACTION</b>	See Form PCT/IPEA/416
International application No. <b>PCT/AU2004/001158</b>	International filing date ( <i>day/month/year</i> ) 27 August 2004	Priority date ( <i>day/month/year</i> ) 29 August 2003
International Patent Classification (IPC) or national classification and IPC  Int. Cl. <sup>7</sup> B01D 21/01, C02F 1/54, 1/56		
Applicant  THE UNIVERSITY OF NEWCASTLE RESEARCH ASSOCIATES LIMITED et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
  - a. ☒ (sent to the applicant and to the International Bureau) a total of 8 sheets, as follows:
 

☒ sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).  
☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
  - b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

- |                                     |              |   |
|-------------------------------------|--------------|---|
| <input checked="" type="checkbox"/> | Box No. I    | Basis of the report   |
| <input type="checkbox"/>            | Box No. II   | Priority  |
| <input type="checkbox"/>            | Box No. III  | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability  |
| <input type="checkbox"/>            | Box No. IV   | Lack of unity of invention  |
| <input checked="" type="checkbox"/> | Box No. V    | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |
| <input type="checkbox"/>            | Box No. VI   | Certain documents cited   |
| <input type="checkbox"/>            | Box No. VII  | Certain defects in the international application  |
| <input type="checkbox"/>            | Box No. VIII | Certain observations on the international application   |

Date of submission of the demand 29 June 2005	Date of completion of the report 13 July 2005
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer  <b>JOHN DEUIS</b> Telephone No. (02) 6283 2146

# INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/AU2004/001158

## Box No. I Basis of the report

1. With regard to the language, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
  - ☐ This report is based on translations from the original language into the following language which is the language of a translation furnished for the purposes of:
    - ☐ international search (under Rules 12.3 and 23.1 (b))
    - ☐ publication of the international application (under Rule 12.4)
    - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:
  - ☐ the international application as originally filed/furnished
  - ☒ the description:
    - pages 1-48 as originally filed/furnished
    - pages\* received by this Authority on with the letter of
    - pages\* received by this Authority on with the letter of
  - ☒ the claims:
    - pages as originally filed/furnished
    - pages\* as amended (together with any statement) under Article 19
    - pages\* 49-56 received by this Authority on 29 June 2005 with the letter of 29 June 2005
    - pages\* received by this Authority on with the letter of
  - ☒ the drawings:
    - pages 1/21-21/21 as originally filed/furnished
    - pages\* received by this Authority on with the letter of
    - pages\* received by this Authority on with the letter of
  - ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.
3. ☐ The amendments have resulted in the cancellation of:
  - ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to the sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
  - ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing (*specify*):
  - ☐ any table(s) related to the sequence listing (*specify*):

\* If item 4 applies, some or all of those sheets may be marked "superseded."

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/AU2004/001158

**Box No. V** Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

## 1. Statement

Novelty (N)	Claims 1-68	YES
	Claims	NO
Inventive step (IS)	Claims 1-68	YES
	Claims	NO
Industrial applicability (IA)	Claims 1-68	YES
	Claims	NO

## 2. Citations and explanations (Rule 70.7)

None of the individual citations disclose all the essential features as claimed. Claims 1-68 are novel and involve an inventive step.

The invention is directed to a method of controlling the conditioning of inter-particle forces between particles in a liquid, wherein the conditioning is reversible.

The closest art found was:

D1: WO 2001/005712 A (CIBA SPECIALTY CHEMICALS WATER TREATMENTS LIMITED)  
25 January 2001

D2: WO 1999/050195 A (CIBA SPECIALTY CHEMICALS WATER TREATMENTS LIMITED)  
7 October 1999

D3: US 5846433 A (SORENSEN ET AL.) 8 December 1998

D4: WO 2002/004360 A (MICROBAR INC.) 17 January 2002

D5: US 6607670 B (BALDWIN ET AL.) 19 August 2003

D6: WO 1999/050188 A (CIBA SPECIALTY CHEMICALS WATER TREATMENTS LIMITED)  
7 October 1999

D7: US 5779910 A (DONLIN) 14 July 1998

D8: US 4997573 A (BROWNE) 5 March 1991

D9: esp@cenet database Abstract JP56091807 A (FUJI KIKAI SEISAKUSHO:KK) 25 July 1981

D10: WO 2001/010530 A (BAKER HUGHES INCORPORATED) 15 February 2001

D11: US 5549827 A (BATSON) 27 August 1996

D12: US 6171506 B (ALLEN ET AL.) 9 January 2001

D13: US 6083404 A (SOMMESE ET AL.) 4 July 2000

D14: US 4178243 A (MESSER) 11 December 1979

D15: US 4273658 A (KARMAN) 16 June 1981

D16: US 4999115 A (PETERSON) 12 March 1991

**THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-**

1. A method of controlling the condition of a suspension of solid particles within  
a liquid including applying one or more stimuli to said suspension, said one or  
more stimuli adapted to control inter-particle forces between said solid  
particles, wherein each stimulus is selectively operable to effect reversibly  
operable conditioning between an initial state prevailing prior to said applying  
one or more stimuli and a conditioned state resultant from said applying one or  
more stimuli, thereby to control interaction between said solid particles within  
said liquid.
2. A method of controlling the consolidation of a bed of solid particles within a  
liquid including applying one or more stimuli to said bed, said one or more  
stimuli adapted to control inter-particle forces between said solid particles,  
wherein each stimulus is selectively operable to effect reversibly operable  
conditioning between an initial state prevailing prior to said applying one or  
more stimuli and a conditioned state resultant from said applying one or more  
stimuli, thereby to control interaction between said solid particles within said  
liquid, said stimulus being applied for a predetermined time thereby to liberate  
at least some liquid otherwise trapped within said bed.
3. A method according to claim 1 or claim 2 wherein said reversibly operable  
conditioning is facilitated by removal of said one or more stimuli.
4. A method according to claim 1 or claim 2 wherein said reversibly operable  
conditioning is facilitated by addition of another of said one or more stimuli.
5. A method according to claim 1 or claim 2 wherein said reversibly operable  
conditioning is facilitated by removal of said one or more stimuli and/or  
addition of another of said one or more stimuli.
6. A method according to claim 2 wherein said bed is a sediment bed, a  
filtercake, or the product of a centrifuge.
7. A method according to claim 1 or claim 2 wherein said conditioning is  
substantially by way of flocculation and/or coagulation.

8. A method according to any one of the preceding claims wherein said inter-particle forces may be attractive or repulsive between said solid particles within said liquid.
- 5 9. A method according to any one of the preceding claims wherein each of said one or more stimuli is applied for a predetermined time, thereby to induce the desired attraction or repulsion and subsequently removed or altered, thereby to effect said reversibility.
- 10 10. A method according to any one of the preceding claims wherein each of said one or more stimuli is a change in pH, temperature, wavelength of light or the absence thereof, chemical additive, or a combination thereof.
11. A method according to claim 10 wherein said stimulus is a change in pH.
12. A method according to claim 10 wherein said stimulus is a change in temperature.
- 15 13. A method according to claim 10 wherein said stimulus is a combination of change in pH and change in temperature, thereby to induce attractive or repulsive inter-particle forces, as desired.
14. A method according to claim 10 wherein said stimulus is by way of exposure to light, or the absence thereof.
- 20 15. A method according to claim 14 wherein said light includes wavelengths within the range of substantially ultraviolet to substantially visible.
16. A method according to claim 14 or claim 15 wherein said light stimulus is applied in combination with variations in pH and/or temperature.
17. A method according to claim 10 wherein said stimulus is provided by way of addition of one or more predetermined chemical additives.
- 25 18. A method according to claim 17 wherein said chemical additive is a single chemical capable of acting as flocculant or dispersant depending on the selection of predetermined process parameters.

19. A method according to claim 17 or claim 18 wherein said chemical additive is in the form of a photosensitive flocculant.
20. A method according to claim 15 wherein said chemical additive is a stimulus-sensitive polymer.
- 5 21. A method according to claim 20 wherein said stimulus-sensitive polymer is a polyelectrolyte.
22. A method according to claim 21 wherein said polyelectrolyte maybe cationic, anionic, non-ionic, or a combination thereof.
23. A method according to claim 21 or claim 22 wherein said polyelectrolyte is adsorbable onto the surface of said solid particles.
- 10 24. A method according to any one of claim 21 to claim 23 wherein said polyelectrolyte adsorbs onto said surface of said particle in a sufficient quantity as to create steric or electrostatic repulsion between said particles.
25. A method according to any one of claim 21 to claim 24 wherein said polyelectrolyte is substantially soluble at pH values where it is substantially charged, thereby to effect dispersion of said suspension.
- 15 26. A method according to any one of claim 21 to claim 25 wherein said polyelectrolyte is substantially insoluble at pH values where it is substantially uncharged, thereby to effect flocculation of said suspension.
- 20 27. A method according to any one of claim 21 to claim 26 wherein said polyelectrolyte is selected from the group consisting of chitosan, polyacrylic acid, polyacrylamides and derivatives thereof, polymethacrylic acid, poly sodium acrylate, polystyrene sulfanate, polysulfanamide, poly(2-vinyl pyridine), poly(vinylpyridinium bromide), poly(diallyldimethylammonium chloride)(DADMAC), poly(diethylamine), poly(epichlorohydrin), polymers of
- 25 quarternised dimethylaminoethyl acrylates, polymers of quarternised dimethylaminoethyl acrylamides, poly(ethyleneimine) and polyglucose amine.

28. A method according to any one of claim 21 to claim 26 wherein said polyelectrolyte is selected from the group consisting of homo- and copolymers prepared from ethylenic unsaturated monomers including methacrylic acid and salts thereof, methacrylamide, acrylamido methyl propyl sulfonic acid (AMPS) and/or styrene sulfonate and salts thereof.
29. A method according to any one of claim 21 to claim 26 wherein said polyelectrolyte is chitosan or polyacrylic acid.
30. A method according to any one of claim 21 to claim 26 wherein said polyelectrolyte is a polysaccharide.
31. A method according to claim 30 wherein said polysaccharide is selected from the group consisting of xanthan, carragenan, agarose, agar, pectin, guar gum, starches and alginic acid.
32. A method according to claim 30 wherein said polysaccharide is a derivatised polysaccharide selected from the group consisting of carboxy methyl cellulose and hydroxy propyl guar.
33. A method according to claim 20 wherein said polymer is temperature-sensitive.
34. A method according to claim 33 wherein said temperature sensitivity is such that said polymer is substantially soluble or substantially insoluble at substantially low temperatures.
35. A method according to claim 34 wherein said temperature sensitivity is such that said polymer is substantially insoluble (thereby to gel) or substantially soluble, at substantially high temperatures.
36. A method according to any one of claim 33 to claim 35 wherein said temperature sensitive polymer is a single polymer, or a combination of polymers.
37. A method according to any one of claim 33 to claim 36 wherein said temperature sensitive polymer is selected from the group consisting of poly(N-

isopropylacrylamide) (poly(NIPAM)), co-polymers of poly(NIPAM) with other polymers such as polyacrylic acid, poly(dimethylaminopropylacrylamide) or poly(diallyldimethylammonium chloride) (DADMAC), polyethylene oxide, poly propylene oxide, methylcellulose, ethyl hydroxyethyl cellulose, carboxymethyl cellulose, hydrophobically modified ethyl hydroxyethyl cellulose, poly dimethylacrylamide/*N*-4-phenylazophenylacrylamide (DMAAm) and poly dimethylacrylamide/ 4-phenylazophenylacrylate (DMAA) and other related polymers, gelatine, agarose, amylase, agar, pectin, carragenan, xanthan gum, guar gum, locust bean gum, hyaluronate, dextran, starches and alginic acid.

38. A method according to any one of claim 33 to claim 36 wherein said temperature sensitive polymer is methylcellulose or poly(NIPAM).
39. A method according to claim 17 wherein said chemical additive is a photosensitive molecule wherein said photosensitivity is manifested in its solubility characteristics.
40. A method according to claim 39 wherein said photosensitive molecule is incorporated within one or more polymers.
41. A method according to claim 39 or claim 40 wherein at least one of said one or more polymers is a water soluble polymer.
42. A method according to any one of claim 39 to claim 41 wherein said polymers suitable for the inclusion of photosensitive units include polypeptides.
43. A method according to claim 42 wherein said polypeptides are selected from the group consisting of lysine and glutamic acid.
44. A method according to claim 39 or claim 40 where said polymer is selected from the group consisting of polyacrylamides, polysaccharides, polyelectrolytes and other water-soluble molecules.
45. A method according to claim 39 wherein said photosensitive units are spiropyrans and/or spirooxazines.



46. A method according to claim 45 wherein said spyropyrans and/or  
spyrooxazines are selected from the group consisting of benzoindolino  
pyranospiran (BIPS), benzoindolino spyrooxazine (BISO),  
naphthalenoindolino spyrooxazine (NISO) and quinolinyndolino  
spyrooxazine (QISO).  
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47. A method according to claim 39 wherein said photosensitive units are azo  
benzene and similar groups, triphenyl methane derivatives and similar groups.
48. A method according to any one of claim 39 to claim 46 wherein said  
photosensitive molecule is triggered by a change in the wavelength of light  
10 from substantially visible to substantially ultraviolet.
49. A method according to claim 48 wherein said polymers responsive to said  
change in wavelength are selected from the group consisting of poly  
dimethylacrylamide/N-4-phenylazophenylacrylamide (DMAAm), poly  
dimethylacrylamide/ 4-phenylazophenylacrylate (DMAA) and similar  
15 polymers.
50. A method according to claim 17 wherein said chemical additive is one or more  
copolymers added to said suspension.
51. A method according to claim 50 wherein component monomers within said  
copolymer may be dispersed randomly, alternately or in blocks.
- 20 52. A method according to claim 51 wherein said copolymer is a block copolymer.
53. A method according to claim 52 wherein said block copolymer is selected  
from the group consisting of AB blocks, ABA blocks, ABC blocks, comb,  
ladder, and star copolymers.
- 25 54. A method according to claim 51 or claim 52 wherein said block copolymer  
includes sectors that variously adsorb to said surface of said particles in  
suspension, and/or are sensitive to a stimulus.

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55. A method according to claim 54 wherein said stimulus is one or more of  
change in pH, change in temperature, change in the wavelength of light, or the  
absence thereof.
56. A method according to any one of claim 52 to claim 55 wherein said  
5 copolymers are selected from the group consisting of polyethyleneoxide-  
polypropyleneoxide-polyethyleneoxide (PEO/PPO/PEO) triblock copolymers.
57. A method according to claim 56 wherein said PEO/PPO/PEO triblock  
copolymer is a Pluronic polymer.
58. A method according to any one of claim 52 to claim 57 wherein said  
10 copolymer includes one or more polypropylene oxide sectors, thereby to  
adsorb particularly to hydrophobic particles, and one or more polyethylene  
oxide sectors thereby to provide inter-particle steric repulsion at  
substantially room temperature.
59. A method according to any one of claim 52 to claim 58 wherein said  
15 copolymer(s) are comb copolymer(s), thereby having a backbone that  
enhances said surface adsorption, and teeth that are stimulus-sensitive.
60. A method according to claim 59 wherein said comb copolymer includes a  
polyacrylic acid backbone and polyethylene oxide teeth.
61. A method according to claim 2 wherein removal of or a change in said  
20 stimulus provides for further settling/consolidation of said particles within said  
sediment bed.
62. A method according to claim 2 or claim 61 wherein said stimulus is a  
chemical additive, added to a suspension prior to formation of said sediment  
bed, thereby to effect substantially thorough mixing of said additive within  
25 said sediment bed.
63. A method of separating solid particles from a liquid including applying the  
method according to any one of the preceding claims, for a predetermined time  
thereby to provide a solids-rich phase and a liquids-rich phase and then  
separating said two phases.

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64. A method according to any one of the preceding claims when used in conjunction with gravimetric thickening devices and/or tailings lagoons.
65. A method according to any one of claim 1 to claim 64 when applied to mineral slurries.
- 5 66. A method of controlling the dispersion of a suspension of solid particles within a liquid substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.
- 10 67. A method for consolidating a sediment bed of solid particles within a liquid substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.
68. A method of separating solid particles from a liquid substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.

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